IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Christian Herlt

Group Art Unit: 3743

Examiner: David J. Laux

Serial No.: 10/595,416

Filed: April 17, 2006

For: Gasification Boiler for Solid Fuels, in Particular for Bales of Straw, With Optimized Gas Values

Attorney Docket No.: HERL 0101 PUSA

APPEAL BRIEF UNDER 37 C.F.R. § 41.37 and PETITION FOR EXTENSION OF TIME UNDER 37 C.F.R. § 1.136(a)

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Commissioner:

Appellant hereby petitions for a two month extension of time to respond to the Office Action mailed October 12, 2011 (Notice of Appeal filed January 12, 2012) thereby extending the time period within which to respond to May 12, 2012.

This is an Appeal Brief from the rejection of claims 1-14 of the Office Action mailed on October 12, 2011 for the above-identified patent application.

I. REAL PARTY IN INTEREST

The Appellant has not assigned its rights, and is under no obligation to assign its rights. Therefore, the Applicant, Christian Herlt, is the real party in interest.

II. RELATED APPEALS AND INTERFERENCES

There are no appeals, interferences or judicial proceedings known to the Appellant, the Appellant's legal representative, or the Assignee which may be related to, directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-14 are pending in this application. Claims 1-14 have been rejected and are the subject of this appeal.

IV. STATUS OF AMENDMENTS

None.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Independent claim 1 provides a gasification boiler for burning entire bales of straw at one time, as illustrated in Figures 1, 2, and 4 reproduced below. "The invention relates to a gasification boiler for the combustion of solid fuels, especially bales of straw, for heating purposes and for the production of hot water." (Figs 1-4; Specification at page 1, ll. 6-9).

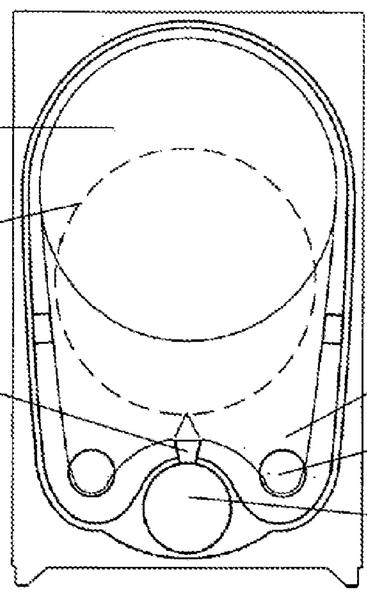


Fig. 1

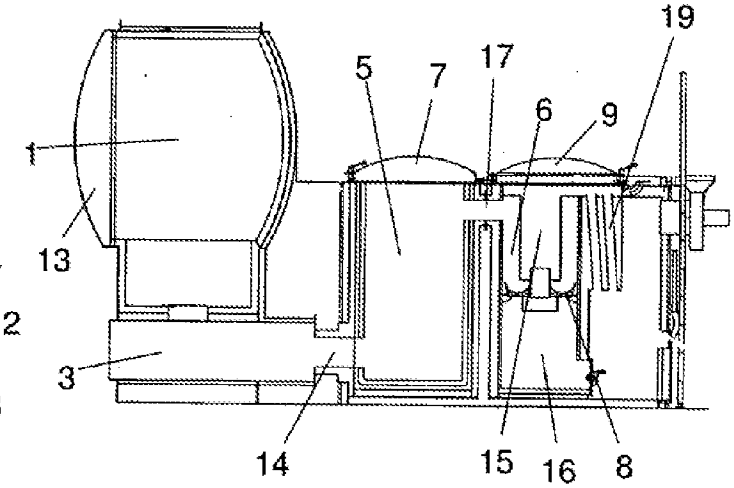


Fig. 2

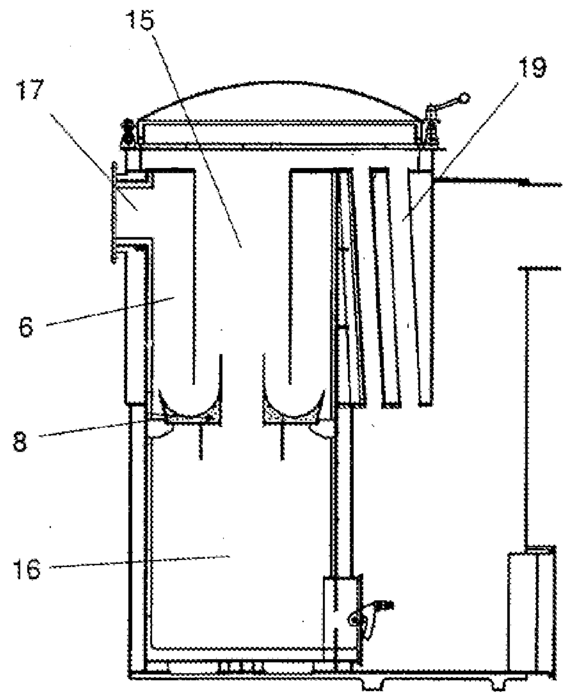


Fig. 4

(Figures 1, 2, and 4 of Specification as submitted on April 30, 2009).

Claim 1 further comprises "[a] fuel and gasification space 1" having a "filling door 13 for the bales of straw 11…." (Fig. 1; Specification at page 3, ll. 29-31, as amended on 4/30/09). "The fuel and gasification space 1 has depressions 4 parallel to the grating 2 and combustion space 3. Said depressions are of half-shell-shaped design. The wall has a respective door in the end region for the removal of ash." (Fig. 1; Specification at pate 4, ll. 3-7). "The loose, heavy particles of the combustion matter accumulate in the outer, lateral depressions 4 where they completely combust." (Fig. 1; Specification at page 3, ll. 27-29). "The coarse particles can outgas in the depressions and do not load the combustion gas flow." (Specification at page 2, ll. 28-30). "At the lower apex of the fuel and gasification space 1, there is a longitudinal slot in the bottom extending over the entire depth. A grating 2 is embedded in said longitudinal slot. Situated below the grating 2 are gas nozzles which lead into a combustion space 3." (Figs. 1-2; Specification at page 3, line 33 to page 4, line 1, as amended on 4/30/09).

A "cylindrical combustion chamber…is connected to the outlet of the combustion space. This aftercombustion chamber considerably extends the combustion time…." (Fig. 2; Specification at page 2, ll. 33-37.) "Ash separator 6 is connected at the top tangentially to the outlet 17 of the combustion chamber 5." (Figs. 2 and 4; Specification at page 4, ll. 11-14, as amended on 4/30/09). "In this ash separator, the remaining ash constituents are removed from the flue gas. The heat exchanger arranged downstream is therefore no longer loaded with ash." (Figs. 2 and 4; Specification at page 3, ll. 6-9).

Claim 3 provides that "[c]ombustion chamber 5 is connected at the bottom tangentially to the outlet 14 of the combustion space 3, so that the combustion gas rises therein in a swirling manner. (Fig. 2; Specification at page 4, ll. 11-14, as amended on 4/30/09). "The tangential introduction of the combustion gas acts as a cyclone, so that further ash accumulates at the bottom." (Fig. 2; Specification at page 3, ll. 1-3).

Claim 4 provides that “a pipe 15 is fitted centrally in the upper region” of the ash separator 6. (Figs. 2 and 4; Specification at page 4, ll. 19-20, as amended on 4/30/09).

Claim 5 provides that a “circular baffle plate 8 is fitted in such a manner that a narrow annular opening for the depositing of ash remains from the outer wall.” (Figs. 2 and 4; Specification at page 4, ll. 20-22, as amended on 5/19/10 and 4/30/09). The ash separator can be closed by a cover (Fig. 2; Specification at page 4, ll. 15-18).

Independent claim 14 is described in substantially the same Figures and portions of the Specification as described above for claims 1 and 3-5, which have been reproduced below.

“The invention relates to a gasification boiler for the combustion of solid fuels, especially bales of straw, for heating purposes and for the production of hot water.” (Figs 1-4; Specification at page 1, ll. 6-9). “A fuel and gasification space 1” having a “filling door 13 for the bales of straw 11….” (Fig. 1; Specification at page 3, ll. 29-31, as amended on 4/30/09). “The fuel and gasification space 1 has depressions 4 parallel to the grating 2 and combustion space 3. Said depressions are of half-shell-shaped design. The wall has a respective door in the end region for the removal of ash.” (Fig. 1; Specification at pate 4, ll. 3-7). “The loose, heavy particles of the combustion matter accumulate in the outer, lateral depressions 4 where they completely combust.” (Fig. 1; Specification at page 3, ll. 27-29). “The coarse particles can outgas in the depressions and do not load the combustion gas flow.” (Specification at page 2, ll. 28-30). “At the lower apex of the fuel and gasification space 1, there is a longitudinal slot in the bottom extending over the entire depth. A grating 2 is embedded in said longitudinal slot. Situation below the grating 2 are gas nozzles which lead into a combustion space 3.” (Figs. 1-2; Specification at page 3, line 33 to page 4, line 1, as amended on 4/30/09).

A “cylindrical combustion chamber…is connected to the outlet of the combustion space. This aftercombustion chamber considerably extends the combustion time….” (Fig. 2; Specification at page 2, ll. 33-37.) “Ash separator 6 is connected at the top tangentially to the outlet 17 of the combustion chamber 5.” (Figs. 2 and 4; Specification at page 4, ll. 11-14, as

amended on 4/30/09). "In this ash separator, the remaining ash constituents are removed from the flue gas. The heat exchanger arranged downstream is therefore no longer loaded with ash." (Figs. 2 and 4; Specification at page 3, ll. 6-9).

"Combustion chamber 5 is connected at the bottom tangentially to the outlet 14 of the combustion space 3, so that the combustion gas rises therein in a swirling manner. (Fig. 2; Specification at page 4, ll. 11-14, as amended on 4/30/09). "The tangential introduction of the combustion gas acts as a cyclone, so that further ash accumulates at the bottom." (Fig. 2; Specification at page 3, ll. 1-3).

"[A] pipe 15 is fitted centrally in the upper region" of the ash separator 6. (Figs. 2 and 4; Specification at page 4, ll. 19-20, as amended on 4/30/09).

A "circular baffle plate 8 is fitted in such a manner that a narrow annular opening for the depositing of ash remains from the outer wall." (Figs. 2 and 4; Specification at page 4, ll. 20-22, as amended on 5/19/10 and 4/30/09). The ash separator can be closed by a cover (Fig. 2; Specification at page 4, ll. 15-18).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 1-2, 4, 6, 8, 10, and 12 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over US 4,498,909 to Milner et al. in view of US 5,901,653 to Jennebach et al., further in view of US 5,720,165 to Rizzie et al. and further in view of US 7,228,806 to Dueck et al.

Claims 3, 5, 7, 9, 11, and 13 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over '909 in view of '653, '165, and '806 as applied to claims 1, 3, and 5 above, and further in view of US 6,758,149 to Oiwa et al.

Claim 14 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over '909 in view of '653, '165, '806, and '149.

VII. ARGUMENT

A. Claims 1-2, 4, 6, 8, 10, and 12 Are Patentable Under 35 U.S.C. § 103(a) Over US 4,498,909 to Milner et al. in View of US 5,901,653 to Jennebach et al., Further in View of US 5,720,165 to Rizzie et al. and Further in View of US 7,228,806 to Dueck et al

Claim 1 Is Separately Patentable

Claim 1 recites:

a gasification boiler for burning entire bales of straw at one time, the boiler comprising:

a fuel and gasification chamber configured to receive an entire bale of straw at one time, the chamber closable by a filling door and having air feeds and depressions for collecting and holding ash resulting from the combustion of the bale of straw, the depressions disposed adjacent to a grating arranged at the bottom of the fuel and gasification chamber and configured to allow coarse straw ash particles to completely combust and not enter a flow of a combustion gas;

a combustion chamber situated below the grating and configured to receive and combust the combustion gas;

a secondary combustion chamber connected to an outlet of the combustion chamber configured to further receive and combust the combustion gas; and

a cylindrical ash separator for collecting fine straw ash particles located downstream from the secondary combustion chamber and having an inlet connected at the top tangentially to an outlet of the secondary combustion chamber, the ash separator having an outlet connected to a heat exchanger.

Accordingly, claim 1 requires that the boiler is able to effectively combust an entire bale of straw at one time. As acknowledged by the Examiner, Milner ('909) fails to disclose a boiler burning bales of straw. (Office Action mailed October 12, 2011; Page 5, Paragraph 12). Rather, Milner teaches a boiler that continuously adds wood and/or wood chips as fuel. (Milner, Col. 1, line 60; Col. 2, lines 35-36; Col. 8, lines 14-15). The fuel is added through a valve 31 into a hopper 33, and then released into the chamber 20 on a continuous basis. (Milner, Col. 2, line 65 to Col. 3, line14). The chamber 20 is therefore not configured to receive a bale of straw for

burning all at one time and Milner teaches away from such a chamber. (See Col. 2, lines 34-44, the constant rate protects the equipment).

The Examiner relies on Dueck ('806) to teach that straw is a type of biomass that may be gasified and burned, and asserts that one of ordinary skill in the art would have used bales of straw as fuel in the Milner boiler. (Office Action mailed October 12, 2011; Page 5, Paragraph 12). Appellant respectfully disagrees with the Examiner's assertion that because Dueck states that all kinds of biomass can be gasified, it would be obvious to use straw bales as fuel in Milner. As stated in the background section of the present application, straw fuel poses particular problems for gasification:

> The fuel comprising bales of straw causes particular requirements. There is the problem of uniform gasification which is obstructed by carbonization of the outer layers. A high content of uncombusted small constituents and a low ash melting point have an unfavorable effect on the exhaust gas values and dirty the heat exchange surfaces….
>
> (Specification at page 2, ll. 5-11).

Attached Exhibits A-C (and translations) were submitted with Applicant's response filed June 15, 2011 and are therefore of record. Exhibits A-C further discuss the difficulties of gasification of straw, which would be known to one of ordinary skill in the art. As stated in Exhibit A, by 1997 wood gasifiers were considered "state of the art," while significant technical problems remained for straw fuel, partially due to higher levels of nitrogen, sulfur, chlorine, and alkalis. (Exhibit A, last paragraph of first page). Exhibit B states that straw has high ash content, a low softening interval, and high amounts of trace elements. (Exhibit B, "problem" paragraph). It further states that straw has up to 10x more ash, 4x more phosphorus, 10x more sulfur, and 100x more chlorine than conventional wood. (Exhibit B, "results" paragraph). Exhibit C, slide 3 states that straw has a 5-15x higher ash content than wood, that straw slags due to high alkali content at temperatures below 800°C, and that straw has higher levels of impurities such as nitrogen, chlorine, and sulfur. Exhibit C, slide 4 shows the relative amounts of impurities in straw (third column) compared to wood, expressed in multiples of wood.

One of ordinary skill in the art is aware of these problems and would not look to Milner, a wood chip boiler, for gasification of straw. Milner issued in 1985, twelve years before Exhibit A states that straw gasification still faces serious obstacles. In addition, Milner teaches using temperatures of about 1100°C to 1300°C, which are much higher than the melting points of salts present in straws (slag occurs at less than 800°C, as noted above in Exhibit C, and some salts in straw have melting points ranging from 300°C to 450°C). Using straw in the boiler of Milner would therefore result in significant slagging, which would accumulate on the grate 26 and progressively arrest the combustion process. In contrast to Milner, the invention of claim 1 avoids slagging by using large quantities of straw at a time, but at low temperature, resulting in a high quantity of fuel gas while avoiding the issues of slagging. It would also not be obvious to look to Milner because he teaches a boiler based on the reverse flow principle, while the present invention operates as a parallel flow gasifier.

Accordingly, one of ordinary skill in the art would not combine the boiler of Milner and the straw fuel of Dueck, because the result would be a boiler that is incapable of effectively combusting an entire bale of straw (even if a bale fits in the reactor can physically fit a bale, as asserted by the Examiner). In contrast, the boiler of Milner would produce excess slag on the grate 26 and prevent further fuel combustion, as described above.

Moreover, "[i]f the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims *prima facie* obvious." (MPEP 2143.01; Section VI (Citing *In re Ratti*, 270 F.2d 810, 123 USPQ 349 (CCPA 1959))). Milner is specifically directed at the gasification of low-ash fuels. (Milner, Column 1, lines 54-59; Column 3, lines 46-49). As discussed above, straw fuel has a substantially higher (5-15x) ash content and therefore would be inappropriate to use as a fuel in the Milner boiler. In addition, the charging of the boiler with a single bale of straw all at one time is a significant departure from the principle of operation of Milner. Milner relies on charging to the gasifier wood chip fuel (having dimensions of about 6 inches long and 4-8 inches in diameter; Column 8, lines 8-9) along with a non-combustible refractory material:

> at an appropriate rate so that the amount supplied, together with the ash that results from combustion of fuel, and taking into account the amount of solids passing from the grate at its operating speed, serves to maintain a sufficient thickness of relatively incombustible material on the grate to protect adequately the grate and its driving mechanism….
>
> (Milner, Column 2, lines 34-42).

Milner continuously feeds and removes fuel and refractory material into/from the boiler in order to maintain a specific layer thickness on the grate. Introducing a bale of straw all at once and not adding fuel during the combustion would completely upset this method of operation. At the beginning of the process, the layer would be too thin on the grate since not enough straw would have combusted. In addition, since straw is relatively less dense than wood, much of the ash that is produced would not settle on the grate but would float upward in the gas stream (the problem the invention of claim 1 seeks to avoid) and not contribute to the grate's protection.

Furthermore, Milner relies on the use of large amounts of small sized fuel in the gasification process:

> The gasification operation in chamber 20 generally involves several sequential effects as the fuel moves downwardly in the bed. In the upper part of the bed, the fuel is partially carbonized, and the fuel becomes further carbonized in the middle portion of the bed. As the fuel descends lower in the bed, it is transformed into charcoal, and the hot charcoal is capable of reacting with superheated steam, yielding carbon monoxide and hydrogen. The lowermost gasification zone in the bed serves to accomplish combustion which provides the heat necessary to support the reduction reactions which give rise to the principal gaseous products, namely, carbon monoxide and hydrogen. The combustion zone 40 is immediately above the ash zone 36 supported on the moving grate.
>
> (Milner, Column 3, lines 31-45).

Since the fuel of Milner is formed as small pieces, each separate piece of fuel is able to descend down the chamber 20 and enter the various zones described above. However, a bale of straw is highly compressed and bounded and therefore the bale as a whole is not able to transition through the multiple zones shown in Fig. 1 of Milner. Instead, for bales of straw pyrolysis starts on the outside surface of the bale and works inward.

Accordingly, the use of a straw bale in Milner would change the principle of operation of the prior art invention being modified, making the teachings of Milner and Dueck insufficient to render the claims prima facie obvious.

Furthermore, the combination of a combustion chamber, secondary combustion chamber, and ash separator would not be obvious based on Milner, Jenneback, and Rizzie because they deal with wood chips and plastics/waste, not straw. (Milner, Col. 1, lines 59-60; Jenneback, Col. 1, lines 24-26; Rizzie, Col. 2, lines 27-30). Combustion of straw uniquely results in loose course particles that can get caught up in the gas flow, but for heavier wood chips and plastics/waste this is not a problem. Therefore there would be no reason to contemplate combining a combustion chamber, a secondary combustion chamber, and an ash separator in series based on the cited references. The only motivation to combine these elements is based on the present application, but such hindsight is impermissible (MPEP § 2142; § 2145(X)(A)).

In light of the above, Appellant respectfully submits that claim 1 is nonobvious over the combination of references. Claims 2, 4, 6, 8, 10, and 12 depend from claim 1 and therefore are nonobvious for at least the reasons stated above with reference to claim 1.

B. Claims 3, 5, 7, 9, 11, and 13 Are Patentable Under 35 U.S.C. § 103(a) Over '909 in View of '653, '165, and '806 as Applied to Claims 1, 3, and 5 Above, and Further in View of US 6,758,149 to Oiwa et al

Claims 3, 5, 7, 9, 11, and 13 depend from claim 1 and therefore are nonobvious for at least the reasons stated above with reference to claim 1.

Claim 5 Is Separately Patentable

Claim 5 recites:

> The gasification boiler as claimed in claim 4, characterized in that a circular baffle plate is fitted below the opening of the pipe in such a manner that a narrow annular opening for the depositing of the fine ash particles between an outer wall of the ash separator and the baffle plate, and in that the ash separator can be closed at the top by a cover.

Claim 5 depends from claim 4, which recites "The gasification boiler as claimed in claim 1 characterized in that a substantially vertical pipe is arranged centrally within the ash separator, the pipe having a lower opening approximately halfway up a height of the ash separator." Accordingly, claim 5 requires a vertical pipe arranged in the ash separator, a circular baffle plate fitted below the opening of the pipe, and a narrow annular opening between the baffle plate and the outer wall of the ash separator for the deposition of ash.

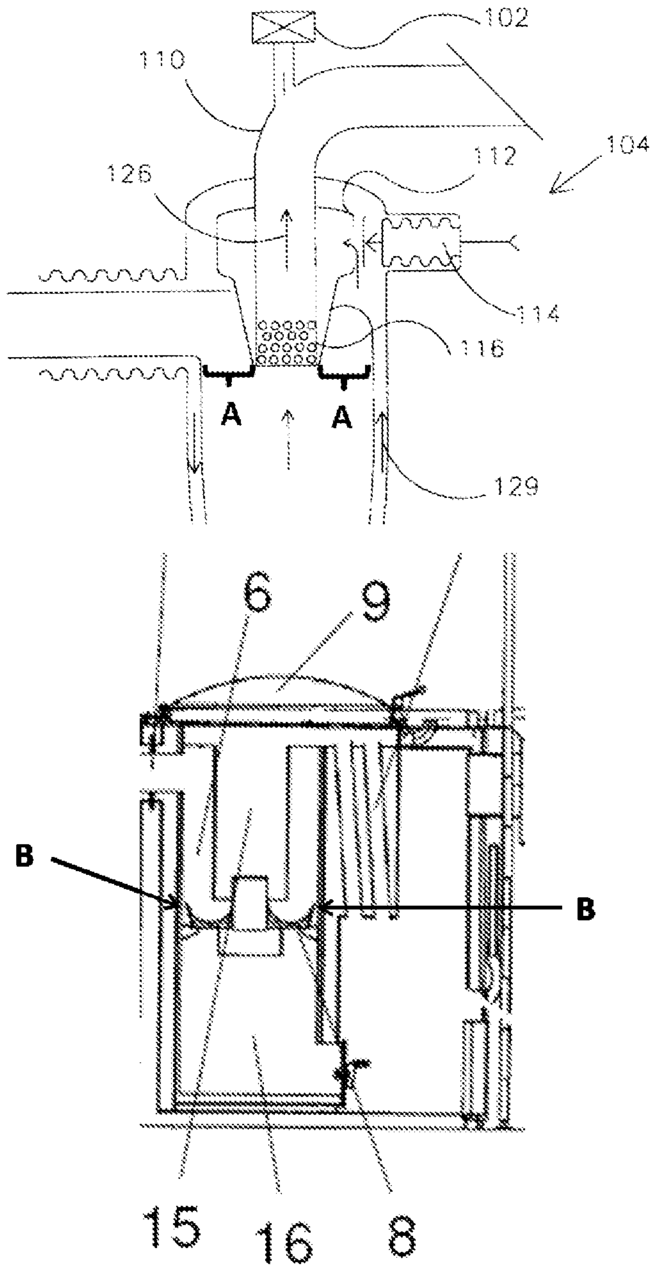
The Examiner states that Rizzie teaches the claimed baffle plate and narrow annular opening, however Appellant respectfully disagrees. The "annular opening" of Rizzie as shown by the Examiner is in no way narrow, but constitutes a majority of the total diameter of the separator 16, as shown below, with "A" representing the space in Rizzie and "B" the space in the present application. Appellant submits that the annular opening in Rizzie cannot be considered to teach the narrow annular opening of claim 5.

Furthermore, Appellant disagrees that the casing 112 of Rizzie can be considered a circular baffle plate, as required by claim 5. As stated in Rizzie:

> In an alternate embodiment shown in FIG. 6, the air bypass assembly 104 includes a casing 112 sealed around the first end of the duct 110 and a pressure controlled bypass flow valve 114. The first end of the duct 110 defines a plurality of openings 116 open to the casing 112. When the valve 114 is opened, air from the cyclone annulus 98 flows into the casing 112, through the plurality of openings 116 and into the duct 110 and combines with the cleaned combustion gas 126…. The flame temperature and cyclone exit air temperature are monitored and controlled with excess air by modulating the bypass flow. The bypassed air 129 is directed into the cyclone exit vortex to decrease cyclone pressure loss and to increase cyclone efficiency during operation of the system.
>
> (Rizzie, Column 7, lines 50-65).

A "baffle," according to the Merriam Webster online dictionary is "a device (as a plate, wall, or screen) to deflect, check, or regulate flow or passage (as of a fluid, light, or sound)." (Exhibit D). Neither the description above nor the shape of the casing 112 indicates that the casing is a device to deflect, check, or regulate flow or passage. Rather, the casing 112 is a

means for admitting air from valve 114 into the gas flow entering duct 110. Even if casing 112 were considered a baffle plate, it would also not be obvious to widen the casing 112 to create the narrow opening of claim 5 because doing so would block the inlet into the separator 16.



In light of the above, Appellant respectfully submits that claim 5 is nonobvious over the combination of references.

C. Claim 14 Is Patentable Under 35 U.S.C. § 103(a) Over '909 in View of '653, '165, '806, and '149

Claim 14 Is Separately Patentable

Claim 14 recites:

A gasification boiler for burning entire bales of straw at one time, the boiler comprising:

a fuel and gasification chamber configured to receive an entire bale of straw at one time, the chamber closable by a filling door and having air feeds and depressions for collecting and holding ash resulting from the combustion of the bale of straw, the depressions disposed adjacent and parallel to a longitudinal grating arranged at the bottom of the fuel and gasification chamber and configured to allow coarse straw ash particles to completely combust and not enter a flow of a combustion gas;

a combustion chamber situated below the grating and configured to receive and combust the combustion gas;

a cylindrical secondary combustion chamber configured to further receive and combust the combustion gas connected at the bottom tangentially to an outlet of the combustion chamber so that the combustion gas rises therein in a swirling manner causing fine straw ash particles to accumulate at a bottom of the secondary combustion chamber;

a cylindrical ash separator for collecting fine straw ash particles located downstream from the secondary combustion chamber and having an inlet connected at the top tangentially to an outlet of the secondary combustion chamber to force the fine ash particles against an outer wall of the ash separator, the ash separator having a substantially vertical pipe arranged centrally therein, the pipe having a lower opening approximately halfway up a height of the ash separator;

a circular baffle plate fitted below the opening of the pipe in the ash separator such that a narrow annular opening exists between the outer wall of the ash separator and the baffle plate to allow for the deposition of the fine ash particles at the bottom of the ash separator after it is pressed against the outer wall of the ash separator; and

a heat exchanger connected to an outlet of the ash separator.

Accordingly, claim 14 requires at least the elements of claims 1 and 5, which Appellant has argued above are patentable over the cited references. The arguments presented above apply

equally to claim 14 and are incorporated herein to avoid redundancy. In addition, claim 14 recites that the depressions are disposed adjacent and parallel to a longitudinal grating. The grating of Milner is cone-shaped and the depressions are not parallel to it but extend away from its base at two locations opposite one another. The shape of the grate 26 and the depressions further exemplify the differences between the claimed invention and Milner. The grate 26 is described in Column 4, lines 29-46 of Milner:

> The grate 26 has base members 50 mounted on an annular table 52 positioned beneath the bottom opening of the lower section 27 of the chamber wall. The grate 26 includes an upper cone-shaped array of annular lower plates 54 mounted on inner upwardly converging supports 56 which are reinforced by rod 58 and are mounted on the base members 50. The upper apex of the cone-shaped array is further supported by a rod 58 extending upwardly from a beam 60 extending across the base 50. The peripheries of the lower plates 54 extend downwardly relative to their interior edges to form upwardly and inwardly extending slanted grate openings into the interior of the cone-shaped grate. The table 52 is mounted on a circular support 62 which is rotatably mounted by a circular bearing 64 on an external support 80 of the gasifier. A driving ring 68 is also mounted on the support 62 being driven by the grate driving mechanism 37 to rotate the table 52.

The above intricate grate system is designed to agitate the small-sized wood chips that are used as fuel in the Milner boiler. In contrast, claim 14 provides a longitudinal grating having depressions parallel and adjacent thereto for collecting light ash particles whirled up from the bale of straw. The grating does not project upward in a cone-shape, but rather extends in a longitudinal direction underneath a bale of straw.

In light of the above, Appellant respectfully submits that claim 14 is nonobvious over the combination of references.

Conclusion

In view of the foregoing, Appellant respectfully asserts that the claims are patentable. Appellant respectfully requests the Board of Patent Appeals and Interferences to overturn the Examiner's rejections.

The Petition fee of $280.00 and Appeal fee of $310.00 as applicable under the provisions of 37 C.F.R. § 41.20(b)(2) are being charged to our Deposit Account No. 02-3978 via electronic authorization submitted concurrently herewith. Please charge any additional fee or credit any overpayment in connection with this filing to our Deposit Account No. 02-3978.

Respectfully submitted,

Christian Herlt

By /Adam R. Southworth/
Adam R. Southworth
Reg. No. 65,407
Attorney/Agent for Appellant

Date: April 20, 2012

BROOKS KUSHMAN P.C.
1000 Town Center, 22nd Floor
Southfield, MI 48075-1238
Phone: 248-358-4400
Fax: 248-358-3351

Enclosure – Appendices

VIII. CLAIMS APPENDIX

1. A gasification boiler for burning entire bales of straw at one time, the boiler comprising:

a fuel and gasification chamber configured to receive an entire bale of straw at one time, the chamber closable by a filling door and having air feeds and depressions for collecting and holding ash resulting from the combustion of the bale of straw, the depressions disposed adjacent to a grating arranged at the bottom of the fuel and gasification chamber and configured to allow coarse straw ash particles to completely combust and not enter a flow of a combustion gas;

a combustion chamber situated below the grating and configured to receive and combust the combustion gas;

a secondary combustion chamber connected to an outlet of the combustion chamber configured to further receive and combust the combustion gas; and

a cylindrical ash separator for collecting fine straw ash particles located downstream from the secondary combustion chamber and having an inlet connected at the top tangentially to an outlet of the secondary combustion chamber, the ash separator having an outlet connected to a heat exchanger.

2. The gasification boiler as claimed in claim 1, characterized in that the depressions of the fuel and gasification chamber are of half-shell-shaped design and run parallel to the combustion chamber and each depression has a small door for the removal of coarse straw ash.

3. The gasification boiler as claimed in claim 1 characterized in that the secondary combustion chamber is cylindrical and connected at the bottom tangentially to the outlet of the combustion chamber, so that the combustion gas rises therein in a swirling manner causing fine

straw ash particles to accumulate at a bottom of the secondary combustion chamber which is closed at the top by a cover.

4. The gasification boiler as claimed in claim 1 characterized in that a substantially vertical pipe is arranged centrally within the ash separator, the pipe having a lower opening approximately halfway up a height of the ash separator.

5. The gasification boiler as claimed in claim 4, characterized in that a circular baffle plate is fitted below the opening of the pipe in such a manner that a narrow annular opening for the depositing of the fine ash particles between an outer wall of the ash separator and the baffle plate, and in that the ash separator can be closed at the top by a cover.

6. The gasification boiler as claimed in claim 1 characterized in that the secondary combustion chamber, the ash separator and the heat exchanger are connected in a framework to form a unitary structure.

7. The gasification boiler as claimed in claim 2 characterized in that the secondary combustion chamber is cylindrical and connected at the bottom tangentially to the outlet of the combustion chamber so that the combustion gas rises therein in a swirling manner and in that the combustion chamber can be closed at the top by a cover.

8. The gasification boiler as claimed in claim 2 characterized in that a substantially vertical pipe is arranged centrally within the ash separator, the pipe having a lower opening approximately halfway up a height of the ash separator.

9. The gasification boiler as claimed in claim 3 characterized in that a substantially vertical pipe is arranged centrally within the ash separator, the pipe having a lower opening approximately halfway up a height of the ash separator.

10. The gasification boiler as claimed in claim 2 characterized in that the secondary combustion chamber, the ash separator and the heat exchanger are connected in a framework to form a unitary structure.

11. The gasification boiler as claimed in claim 3 characterized in that the secondary combustion chamber, the ash separator and the heat exchanger are connected in a framework to form a unitary structure.

12. The gasification boiler as claimed in claim 4 characterized in that the secondary combustion chamber, the ash separator and the heat exchanger are connected in a framework to form a unitary structure.

13. The gasification boiler as claimed in claim 5 characterized in that the secondary combustion chamber, the cylindrical ash separator and the heat exchanger are connected in a framework to form a unitary structure.

14. A gasification boiler for burning entire bales of straw at one time, the boiler comprising:

a fuel and gasification chamber configured to receive an entire bale of straw at one time, the chamber closable by a filling door and having air feeds and depressions for collecting and holding ash resulting from the combustion of the bale of straw, the depressions disposed adjacent and parallel to a longitudinal grating arranged at the bottom of the fuel and gasification chamber and configured to allow coarse straw ash particles to completely combust and not enter a flow of a combustion gas;

a combustion chamber situated below the grating and configured to receive and combust the combustion gas;

a cylindrical secondary combustion chamber configured to further receive and combust the combustion gas connected at the bottom tangentially to an outlet of the combustion chamber so that the combustion gas rises therein in a swirling manner causing fine straw ash particles to accumulate at a bottom of the secondary combustion chamber;

a cylindrical ash separator for collecting fine straw ash particles located downstream from the secondary combustion chamber and having an inlet connected at the top tangentially to an outlet of the secondary combustion chamber to force the fine ash particles against an outer wall of the ash separator, the ash separator having a substantially vertical pipe arranged centrally therein, the pipe having a lower opening approximately halfway up a height of the ash separator;

a circular baffle plate fitted below the opening of the pipe in the ash separator such that a narrow annular opening exists between the outer wall of the ash separator and the baffle plate to allow for the deposition of the fine ash particles at the bottom of the ash separator after it is pressed against the outer wall of the ash separator; and

a heat exchanger connected to an outlet of the ash separator.

IX. EVIDENCE APPENDIX

Exhibit A: Christine Rösch & Detlef Wintzer, *Gasification and pyrolysis of biomass*, TAB report no. 49 (1997).

Exhibit B: Manfred Wörgetter, *Straw gasification and slagging with plasma technology, dry gascleaning*, Biomass Logistics Technology 2005 Annual Report, http://blt.josephinum.at/?id=773.

Exhibit C: Ute Bauermeister, *First results on straw gasification-Comparative studies in the laboratory and the industrial scale*, GNS - Society for Sustainable Substance Use.

Exhibit D: Definition of "baffle" from Merriam-Webster Online Dictionary (visited April 18, 2012).

Exhibit A

A

BÜRO FÜR TECHNIKFOLGEN-ABSCHÄTZUNG
BEIM DEUTSCHEN BUNDESTAG

Christine Rösch • Detlef Wintzer

Gasification and pyrolysis of biomass

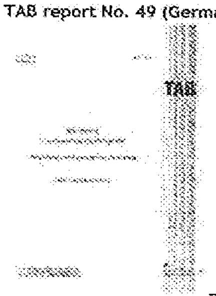
TAB report no. 049. Berlin 1997, 116 pages

Summary

The gasification of biomass is a developing energy technology among various systems for the energetic utilisation of biomass which has the following main advantages compared to conventional combustion technologies:

The combined heat and power generation via biomass gasification techniques connected to gas-fired engines or gas turbines can achieve significantly higher electrical efficiencies between 22 % and 37 % compared to biomass combustion technologies with steam generation and steam turbine (15 % to 18 %). If the produced gas is used in fuel cells for power generation, an even higher overall electrical efficiency can be attained in the range between 25 % and 50 %, even in small scale biomass gasification plants and under partial load operation.
Due to the improved electrical efficiency of the energy conversion via gasification, the potential reduction in CO2 is greater than with combustion. The formation of NOx compounds can also be largely prevented and the removal of pollutants is easier for various substances. The NOx advantage, however, may be partly lost if the gas is subsequently used in gas-fired engines or gas turbines. Significantly lower emissions of NOx, CO and hydrocarbons can be expected when the produced gas is used in fuel cells instead of using it in gas-fired engines or gas turbines.

TAB report No. 49 (German)



[4.68 MB]

The printed report can be requested free of charge (buero@tab-beim-bundestag.de).
BibTeX | RIS

Further information (German)

Information on the project

Contact

Dr. Christine Rösch
christine.roesch@kit.edu
Fon +49 721 608-22704

Pyrolysis of biomass generates three different energy products in different quantities: coke, oils and gases. Flash pyrolysis gives high oil yields, but because of the technical efforts needed to process pyrolytic oils this energy generating system does not seem to be very promising at the present stage of development. However, pyrolysis as a first stage in a two-stage gasification plant for straw and other agricultural feedstocks posing technical difficulties in gasification does deserve consideration.

In most biomass gasification processes, air is used as gasifying agent with the result, that a low calorific value gas (3-5 MJ/m³) is generated, which can be used after cleaning in gas-fired engines or gas turbines. For gas turbines connected to a steam turbine, medium calorific value gas (12-15 MJ/m³) is more favourable than low calorific gas. Steam injection into the gas turbine combustion chamber (Cheng process) requires at least medium calorific value gas. The production of methanol or hydrogen via biomass gasification or the use of producer gas in low-temperature fuel cells also require either gasifiers operating with highly-enriched oxygen and steam or indirectly heated (allothermic) gasifiers must be used with steam as a gasification medium to generate the necessary medium calorific value raw gas with high hydrogen content.

Gasification of wood and wood-type residues and waste in fixed bed or fluidised bed gasifiers with subsequent burning of the gas for heat production is state of the art. The wood gasifiers employed primarily in the Scandinavian countries are used almost entirely for heat generation. Significantly greater technical problems are posed by gasification of straw and other solid agricultural feedstocks, which mostly have higher concentrations of nitrogen, sulphur, chlorine and alkalines. The gasification of herbaceous biomass is still at an early stage of research and development. Intensified

Exhibit A

development efforts on gasification technologies for herbaceous biomass feedstocks are desirable as the potential supply of this group of fuels is comparatively large.

Thorough gas cleaning and perfect adaptation of the gas from biomass gasification to the specific requirements of the gas utilisation systems are the prerequisites for gas use in gas-fired engines, gas turbines and fuel cells. Tar compounds can be removed effectively by increasing the gas temperature or by catalytic tar cracking with dolomite or nickel. However, even for wood gasifiers there is still no economically viable solution of the tar problem. None of the gasifier types currently on the market have been successfully tested in connection to gas-fired engines in long term operation under practical conditions in combined heat and power stations.

Under EU demonstration projects, integrated biomass fluidised bed gasifiers with combined cycles (gas and steam turbines) and with an electrical capacity of 5 MW and more are planned, being under construction or in operation. Both gasifiers operating under atmospheric conditions and under pressure (up to 20 bar) and with cold or hot gas cleanup systems are involved in the EU demonstration programme. With pressurised gasification higher overall electrical efficiencies can be achieved, but greater technical and financial resources are required to feed the biomass into the gasifier, and problems with gas cleaning may occur.

For power plants with integrated biomass gasification in the range 3 to 20 MWel, biomass fluidised bed gasification under atmospheric pressure connected to gas turbines, Cheng cycles or gas and steam turbines (IGCC) appear to be the most promising technology at present in technical and economic terms. For combined heat and power stations with capacities up to about 2 MWel, gas use in gas-fired engines is currently more interesting than gas use in gas turbines. Because of problems with fuel supply and logistics, biomass gasification plants with capacities above approximately 30 MWel are not a suitable size for biomass gasification plants in Germany and most other European countries.

The joint combustion of biomass in existing large coal-fired power stations (100 MWel) is currently being investigated in different countries. The integration of biomass-fuelled gasifiers in coal-fired power stations would have different advantages over stand alone biomass gasification plants. Of importance are the greater flexibility in response to annual and seasonal fluctuations in biomass availability and the lower investment costs for the biomass gasification unit.

In case the cleaned and upgraded producer gas is used in fuel cells for power production, the low-temperature proton exchange membrane fuel cell (PEMFC) and the high-temperature molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC) are more attractive in the longer term because of their higher overall electrical efficiency than the medium-temperature phosphoric acid fuel cell (PAFC). Power generation in high-temperature MCFC or SOFC with integrated biomass gasification also has the advantages that no separate unit is needed for CO-shift reaction prior to gas injection into the fuel cell, and that in addition to electricity, process heat is provided by the fuel cell at a high temperature level. For the PEMFC and MCFC, which are on the threshold of the demonstration phase, several companies are aiming to move into small series production in the next few years.

Although each of the fuel cell types listed above has made substantial advances in technological development in recent years, all three types still have several major technical problems to overcome. It remains to be seen which type will overcome its problems most successfully. The start of series production should in any case significantly reduce the present cost disadvantage compared to other gas utilisation techniques. To reach the point of technological maturity for fuel cell systems with integrated biomass gasification (IGFC), extensive R&D work going beyond fuel cell technology is necessary.

Under the frame conditions currently reigning on the energy market there is little motivation for plant manufacturers and potential operators to fund the bulk of R&D work themselves. In this situation, encouraging R&D activities requires not only promoting application related demonstration projects but also R&D in the field of gasification, gas cleaning and gas utilisation. Promotion of further research, development and demonstration projects is recommended, with priority for the following areas:

- Demonstrating low-outage plant operation with an integrated biomass gasification plant (initially wood), a gas cleaning system and gas use in gas motors and gas turbines in regular operation in technical test installations and subsequently in demonstration units.
- Development and technical demonstration of gasifiers for straw and other straw-type biomass and associated gas cleaning processes.
- Integration of units for gasifying or pyrolysing biomass into existing large coal-fired power stations.
- Experimental testing of combining processes for biomass gasification, gas cleaning and gas use in fuel cells.

Exhibit A

At present, biomass gasification is starting from an even less favourable economical position than energy use of biomass through combustion, as the technically attractive gasification systems are in an earlier phase of development and demonstration. Assessments on the cost-effectiveness of energy generating systems with integrated biomass gasification have to be proven by practical experience in regular operation. There are, nevertheless, indications that technical advances in developing reliable systems for biomass gasification and efficient gas utilisation can lead to economical advantages over combustion. However, they can only raise heat and power generation from biomass above the break-even point if there is also a significant change in the frame conditions, for example through greater financial reward for the environmental benefits associated with biomass utilisation for energy production. Otherwise the market for biomass gasifiers in Germany and Europe will be limited for the foreseeable future to the treatment of organic wastes (e. g. process residues from the cellulose, paper and sugar industries).

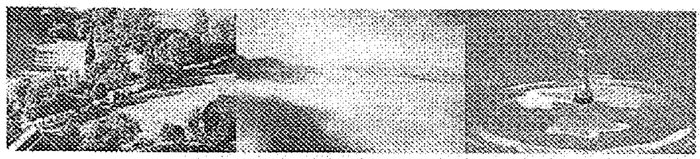
Created: 02/18/2011 Updated: 02/18/2011

Office of Technology Assessment at the German Bundestag

Neue Schönhauser Straße 10, 10178 Berlin | buero@tab-beim-bundestag.de | Tel +49 30 28491-0

Exhibit A

B



Strohvergasung
Straw gasification with slagging and plasma technology, dry gascleaning (BLT 043452)

Projektverantwortlicher an FJ-BLT: Dipl.-Ing. Manfred Wörgetter

Beteiligte Institutionen bzw. Kooperationspartner:

- Austrian Bioenergy Centre GmbH (Projektleitung)
- Institut für Verfahrenstechnik, Umwelttechnik und Techn. Biowissenschaften, TU-Wien
- Institut für Verfahrenstechnik des industriellen Umweltschutzes, MOU Leoben
- New Plasma GmbH&CoKEG
- FEX-ÖKO-Faserverarbeitungs-GmbH
- Rath Chamottewaren- und Thonöfenfabrik, Aug. Rath jun. GmbH

Problem-/Aufgabenstellung:

Die Vergasung ist eine Schlüsseltechnologie für die Entwicklung von biomassebasierten Energiesystemen. Durch die thermochemische Umsetzung der festen Biomasse wird ein Gas erzeugt, das zur Strom- und Wärmeerzeugung und für Synthesen eingesetzt werden kann. Auch bei kleinen und mittleren Anlagen zur gekoppelten Strom- und Wärmeerzeugung lassen sich damit günstige elektrische Ausbeuten erzielen. Allerdings konnten sich Stroh und Ganzpflanzen mit ihren ungünstigen verbrennungstechnischen Eigenschaften (hohe Aschegehalte, Aschen mit niedrig liegendem Erweichungsintervall und hohen Gehalten an Spurenstoffen) als Rohstoff für Vergasungsanlagen nicht etablieren.

Im Rahmen des Projektes soll durch gezielt herbeigeführte Ascheschmelze ein Konzept zur Vergasung von Stroh- und Ganzpflanzenprodukten erstellt werden, welches fähig ist, in einem Durchlaufprozess die Biomasse unter vollständiger Ausnützung des enthaltenen Kohlenstoffes in ein energetisch und stofflich verwertbares Produktgas umzusetzen. Um den Prozess mit ausreichender Energiedichte des Brennstoffes betreiben zu können wird pelletiertes Stroh verwendet.

Ergebnisse:

Entsprechend den brennstofftechnischen Eigenschaften des Strohs wurde das Vergasungssystem ausgelegt. Die Effizienz der Brennstoffumsetzung und die Gasqualität wurden untersucht und beurteilt.

Stroh, ein Nebenprodukt der Landwirtschaft, zeichnet sich durch besondere Eigenschaften aus: Die Struktur ist durch Halmteile und Knoten geprägt, die Rohdichte ist sehr gering. Stroh besitzt außen eine wachsartige Deckschicht, die nicht mit der Holzrinde vergleichbar ist. Durch den raschen Aufwuchs der Pflanzen sind viele Asche bildende Stoffe mineralischen Ursprungs eingelagert. Der Aschegehalt ist bis zu 10-mal höher wie bei Holz. Durch die landwirtschaftlichen Kulturbedingungen unterliegen K, Na, Cl einer breiten Variation. Stroh enthält bis zu 4-mal mehr Phosphor, bis zu 10-mal mehr Schwefel und bis zu 100-mal mehr Cl als Holz. Es ist daher mit anderen Reaktionsbedingungen und anderen Verunreinigungen des Produktgases zu rechnen. Durch die mineralische Zusammensetzung der Aschen kann Erweichung ab 800 °C und Aufschmelzen bei 1200 °C auftreten.

Die abweichende Faserstruktur besitzt bei gleicher Bezugsmasse eine ungleich höhere äußere Oberfläche und damit Reaktionsfläche. Daraus resultieren unterschiedliche Vergasungsverläufe. Der Pyrolysevorgang setzt verzögert ein, durch die rasche Aufheizung werden die Pyrolyseprodukte rasch freigesetzt. Etwa 70 % der Trockensubstanz werden in Gase und kondensierbare Öle umgesetzt. Der Restkoks ist durch die Anreicherung der Asche charakterisiert. Die Reaktivität des Kokses beeinflusst die Gesamtumsetzung von Stroh maßgeblich. Die Korngröße und die Festigkeit des Kokses sind gering, weshalb nicht mit ruhenden Koksschüttungen gearbeitet werden kann. Die Pyrolyseprodukte müssen einer abschließenden Vergasung unterzogen werden, wobei der kondensierbare Produktanteil weitgehend eliminiert werden muss (Reformierung mit Wasserdampf und Kohlendioxid und thermischer Zerfall bei hohen Temperaturen).

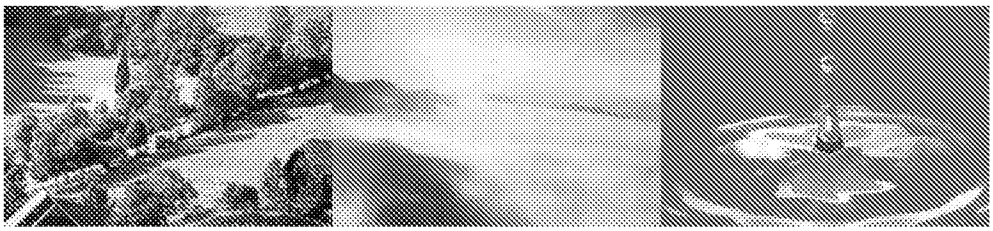
Unter oxidierenden Bedingungen treten lokale Temperaturspitzen auf, die eine mikroskopische Aufschmelzung der Asche zu Schlacke bewirken. Unter Vergasungsbedingungen wird geringeres Aufschmelzen erwartet. Um Schlackeanbackung zu vermeiden ist man bestrebt, mit schmelzflüssigen Asche/Schlackegemengen zu vergasen.

Weitere Informationen können bei Herrn Dipl.-Ing. Manfred Wörgetter per E-Mail oder über die Fax-Nummer +43 (7416) 52175-45 angefordert werden.

< ^

Exhibit B - Translation

BLT
- The BLT
- Tasks
- History
- Building
- Area map
- Activity Reports
- Report 2007 in Web form
- 2006 report in web form
- 2005 report in web form
- Preface
- Organisation
- Research and development projects
- Testing and verification activities
- Cooperation in education
- Other activities
- Departmental Research BMLFUW
- Projects with ABC
- International research cooperation
- Services on behalf of the BMLFUW
- Publications, lectures
- Appendix: Scope of accreditation by FJ-BLT
- Report 2004 in web form
- 2003 report in web form
- 2002 Report on Web-form
- 2001 report in web form
- Departments
- Biomass
- Logistics
- Technology
- Service



Straw gasification
Straw gasification and slagging with plasma technology, dry gascleaning (BLT 043 452)

Project Manager at FJ-BLT: Dipl.-Ing. Manfred Wörgetter

Participating institutions and cooperation partners:

- Austrian Bioenergy Centre GmbH (Project Management)
- Institute of Process Engineering, Environmental and Technical Biology, Technical University of Vienna
- Institute of Process Engineering of industrial environmental protection, MOU Leoben
- New Plasma GmbH & CoKEG
- FEX-ECO-fiber processing GmbH
- Rath Chamottewaren and Thonöfenfabrik, Aug. Rath jun. GmbH

Problem-/Aufgabenstellung:

Gasification is a key technology for the development of biomass-based energy systems. By thermochemical conversion of solid biomass produces a gas that can be used to generate electricity and heat production and synthesis. Even for small and medium-sized plants for cogeneration of electricity and heat generation can be achieved so cheap electrical yields. However, whole crop straw and could, with their poor combustion properties (high ash content, ash having a low softening interval and high contents of trace elements) as feedstock for gasification plants do not establish.

The project is to be created by selectively induced ash melt a concept for the gasification of straw and whole plant products, which is able to implement in a continuous process of biomass in full utilization of the carbon contained in an energy-and material usable product gas. To operate the process with sufficient energy density of the fuel can pelleted straw is used.

Results:

According to the fuel properties of the straw gasification system was designed. The efficiency of fuel conversion and gas quality were examined and assessed.

Straw, a by-product of agriculture, is characterized by specific properties: The structure is characterized by culm and nodes, the density is very low. Straw has a waxy outer layer that is not comparable to the bark. The rapid regrowth of the plants many ash-forming substances are incorporated mineral origin. The ash content is up to 10 times higher than conventional wood. By the agricultural crop conditions are subject to K, Na, Cl a wide variation. Straw containing up to 4 times more phosphorus, up to 10 times more sulfur and up to 100 times more than wood Cl. It is, therefore, reaction conditions and other impurities in the product gas can be expected with others. By the mineral composition of the ash softening can occur from 800 ° C and melting at 1200 ° C.

The different fiber structure has the same reference ground a much greater external surface area and thus reaction. This results in different gasification curves. The pyrolysis process uses delayed by the rapid heating of the pyrolysis products are rapidly released. About 70% of dry matter are converted into gases and condensable oils. The residual coke is characterized by the accumulation of ash. The reactivity of the coke affects the overall implementation of straw significantly. The grain size and the strength of the coke is low, and therefore can not be done with dormant coke charge. The pyrolysis products must undergo a final gasification, wherein the condensable product content must be largely eliminated (reforming with water vapor and carbon dioxide and thermal breakdown at high temperatures).

Under oxidizing conditions, local temperature peaks occur, resulting in a microscopic melting of the ash to slag. Under gasification conditions reduced melting is expected. To avoid Schlackeanbackung, the aim is to gas with molten ash / slag mixtures.

For more information on Mr. Dipl.-Ing. Manfred Wörgetter via e-mail the fax number +43 (7416) 52175-45 requested or be.

BLT - Biomass · Logistics Technology · Francisco Josephinum
A-3250 Wieselburg, rotting Straße 1 - Tel: +43 7416 52175-0 Fax: +43 52 175 7416 45 Mail: blt@josephinum.at

Exhibit B

C

Gesellschaft für Nachhaltige Stoffnutzung mbH GNS

Erste Ergebnisse zur Strohvergasung – Vergleichende Untersuchungen im Labor und im technischen Maßstab

Dr. Ute Bauermeister

GNS – Gesellschaft für Nachhaltige Stoffnutzung mbH
www.GNS-Halle.de
Weinbergweg 23, 06120 Halle, Tel./Fax: 0345/ 5583-754 /-706
e-mail: GNS-Halle@t-online.de

Gesellschaft für Nachhaltige Stoffnutzung mbH GNS

Gliederung:

1. Probleme und Besonderheiten von Stroh als Vergasungsgut
2. Eigenschaften von Biomassepellets im Vergleich
3. Ergebnisse im Laborreaktor
4. Ergebnisse an technischen Pilotanlagen
5. Zusammenfassung

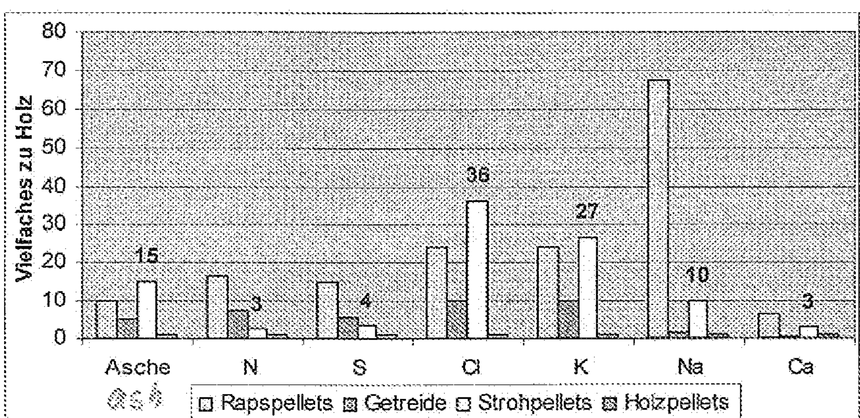
Eigenschaften von Stroh im Vergleich zu Holz

- **Unterscheidung in Form, Festigkeit, Schüttdichte und Energiedichte**
  Auswirkung auf Lagerung (Staubentwicklung),
  Durchsatz (Energiedichte von Strohhäcksel ca. 0,8 GJ/m³, von Holz ca. 4 GJ/m³),
  Dosierung und Vergasungsverhalten (u.a. Druckverluste im Festbettreaktor),
  Staubgehalt im Rohgas
- **Erhöhter Aschegehalt von Stroh gegenüber Holz**
  5 - 15-fach höherer Aschegehalt von Stroh gegenüber Holz,
  Verschlackungsneigung durch den hohen Alkaliengehalt (Ascheerweichung < 800 °C)
- **Erhöhter Gehalt an N, Cl, S von Stroh und Getreide gegenüber Holz**
  brennstoffbedingt höhere Verunreinigungen von N-, S- und Cl-Verbindungen im Rohgas als bei Holz, mit Auswirkungen auf die Gasreinigung

1

Inhaltsstoffe von Biomassen im Vergleich zu Holz

multiple of wood



straw pellets

Mittelwerte, Messungen GNS

2

Gesellschaft für Nachhaltige Stoffnutzung mbH GNS

Besonderheiten von Stroh als Vergasungsgut

Notwendigkeit der Konfektionierung

- Festbettreaktor: niedriger Feinanteil, Kompaktierung oder Pelletierung
- Wirbelbettreaktor: homogene Zerkleinerung
- generell: niedriger Wassergehalt

Berücksichtigung des Schmelzverhaltens der Asche

- Vermeidung der Verschlackung durch Zusätze oder Temperaturbegrenzung
- Alternativ Vergasungstechnik mit Bildung einer schmelzflüssigen Schlacke bei hohen Temperaturen (Schlackebadvergaser)

Neue Anforderungen an die Gasreinigung

- Abscheidung von anorganische Verbindungen aus dem Rohgas
- Abscheidung höherer Staubfrachten

Gesellschaft für Nachhaltige Stoffnutzung mbH GNS

Verunreinigungen im Rohgas

Teere (200 – 4000 mg/Nm³) insbes. abh. vom Verfahrenstyp	**Halogen-Verbindungen (Chlorid)** abh. von der Biomasse
Partikel (100 – 1000 mg/Nm³) abh. von Brennstoff und Verfahren	**N-Verbindungen (NH_3)** (100 – 7000 mg/Nm³) abh. von der Biomasse
Alkalien, flüchtige Schwermetalle abh. von der Biomasse	**S-Verbindungen (Sulfid, Sulfat)** abh. von der Biomasse

Partikelgebundene Verunreinigungen:
kondensierbare Teere, Alkali-, Erdalkali- und Schwermetalle, Koks, Asche, Bettmaterial
Lösliche Verunreinigungen:
lösliche organische Verbindungen („Teere") und anorganische Verbindungen

Strategien zur Vergasung mit geringer Teerbildung

Vorteil der Gleichstromvergasung gegenüber der Gegenstrom-vergasung und Wirbelbettvergasung (Teerspaltung in der Oxidationszone)

Vorteil der 2-stufigen Vergasung (Verbrennung des verunreinigten Pyrolysegases, Gaserzeugung nur aus dem Koks)

Optimierte Prozessführung mit geringen Schwankungen hinsichtlich (einer niedrigen) Brennstoffeuchte, konstantem Temperaturprofil, angepasstem An- und Abfahrregime (Teerspitzen vermeiden)

Optimierte Prozessführung durch das katalytisch-partiellallotherme Verfahren von GNS mit reduzierter Teerbildung in der Pyrolyse

Biomassevergasung nach dem GNS-Verfahren

1. Umstellung des Prozesses auf eine katalytische Steuerung, wobei der Katalysator als billiges Verbrauchsmaterial dem Brenngut vor der Aufgabe in den Reaktor in einem sehr kleinen Anteil zudotiert wurde

2. Durchführung des Verfahrens partiell allotherm, indem ein Teil der anfallenden Abwärme dem Prozess wieder zugeführt wird (Brennstofftrocknung, Luftvorwärmung, geringe Dampfzugabe, Rezirkulation).

Vorteile des patentierten GNS-Verfahrens:

- **Steigerung von Durchsatz, Kaltgaswirkungsgrad und Stromausbeute**
- **hohe Gasreinheit (wenig Teere), hoher Gasheizwert**
- **Möglichkeit der Temperaturkontrolle durch Dampfzugabe**

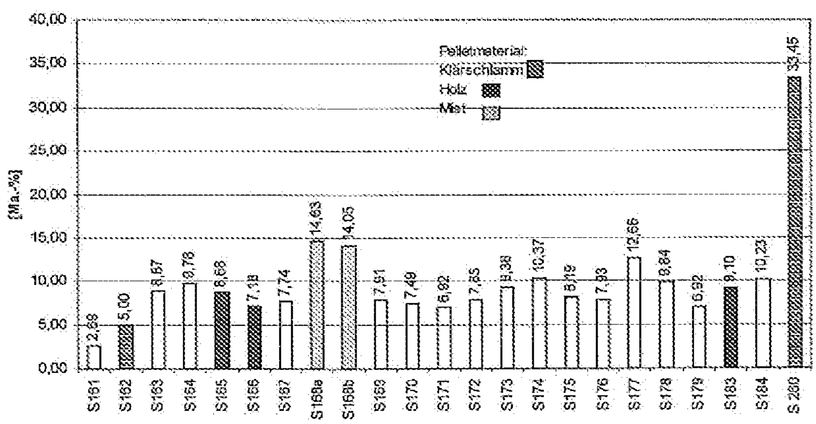
Gesellschaft für Nachhaltige Stoffnutzung mbH GNS

Erste Untersuchungen zur Gaserzeugung aus Stroh und strohhaltigen Biomassen

- Untersuchung der (thermo-)chemischen Eigenschaften insbesondere von Stroh, Mist, Klärschlamm und Holz (chemische Analyse, Thermoanalyse)
- Untersuchungen zur Vorbehandlung, d.h. Trocknung, Zerkleinerung, Kompaktierung, Pelletierung, Siebanalyse, Druckverlustbestimmung
- Vergleichende Vergasungsversuche im Labormaßstab
- Vergleichende Vergasungsversuche an zwei technischen Pilotanlagen mit ca. 50 kW_{el} (Zusammenarbeit mit FÖST e.V. und FBZ e.V.)
  - Forschungs- und Pilotanlage Merseburg (Gleichstrom-Festbettreaktor)
  - Versuchsanlage der Uni Halle (kombinierte Pyrolyse mit stationärer Wirbelschicht)

Gesellschaft für Nachhaltige Stoffnutzung mbH GNS

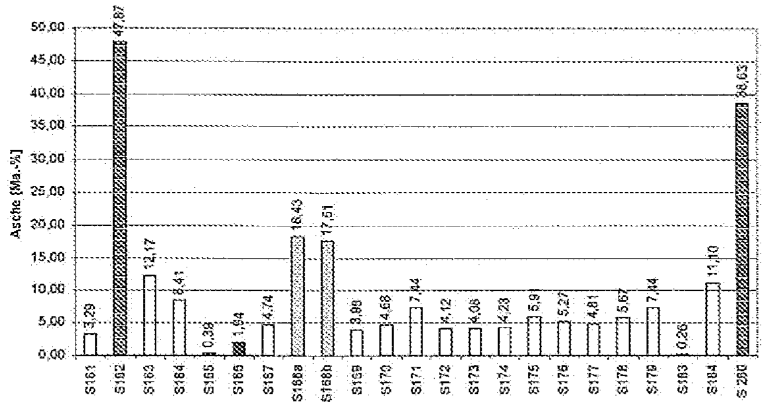
Eigenschaften von Biomassepellets im Vergleich:
Wassergehalt



Gesellschaft für nachhaltige Stoffnutzung mbH

Eigenschaften von Biomassepellets im Vergleich:

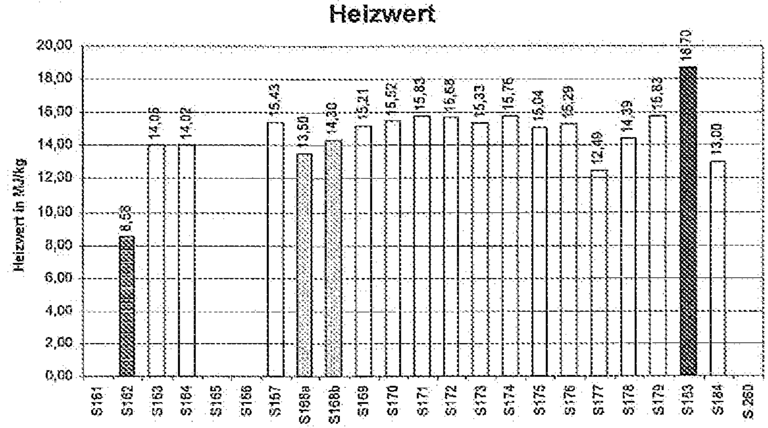
Aschegehalt



Gesellschaft für nachhaltige Stoffnutzung mbH

Eigenschaften von Biomassepellets im Vergleich:

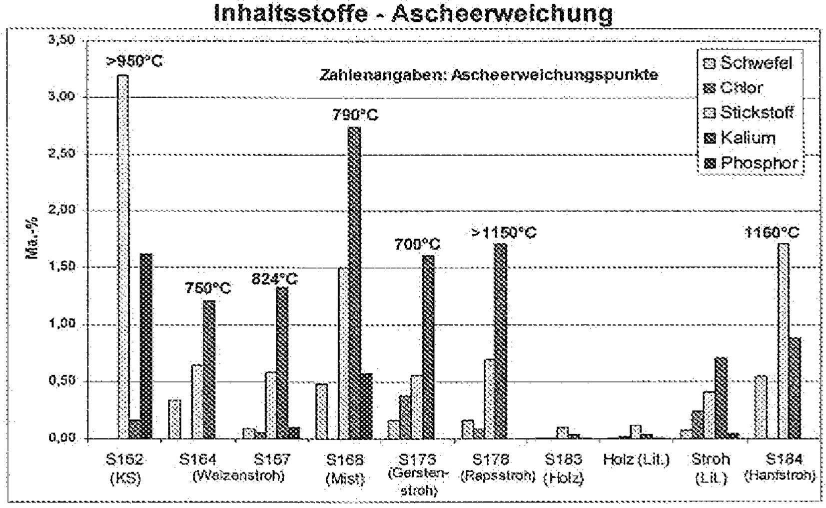
Heizwert



- höhere Anteile an Asche und Wasser korrespondieren mit entsprechend niedrigeren Heizwerten der Pelletproben

Gesellschaft für nachhaltige Stoffnutzung mbH
GNS

Eigenschaften von Biomassepellets im Vergleich:
Inhaltsstoffe - Ascheerweichung



Gesellschaft für nachhaltige Stoffnutzung mbH
GNS

Vergasungsversuche im Labor

Versuchsbedingungen:

diskontinuierliche Versuche

2 getrennt regelbare Röhrenreaktoren (bis 1000°C)

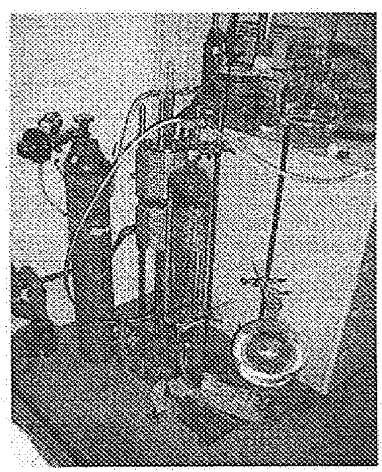
definierte Aufheizgeschwindigkeit

Vergasungstemperatur 700 °C

Vergasungsmedien: Luft, Dampf

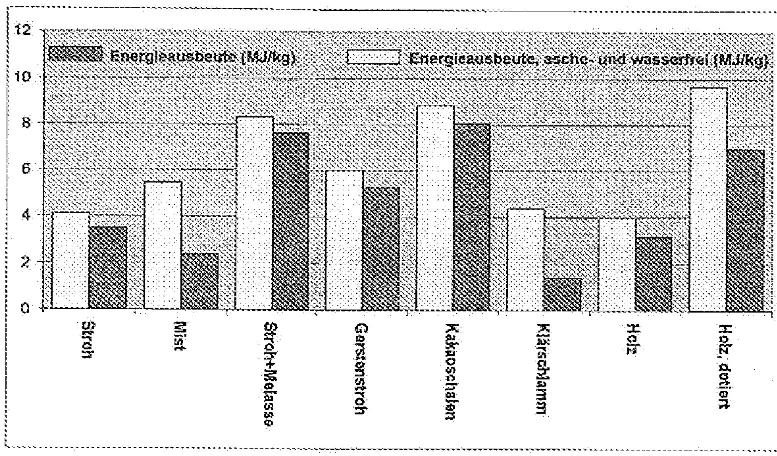
Gasmengenerfassung (auch getrennt nach Thermolyse und Reaktolyse)

Reinigung mit Wasser oder RME



Gesellschaft für Nachhaltige Stoffnutzung mbH
GNS

Energieeffizienz der Vergasung von Biomassepellets im Vergleich zu Holzhackschnitzeln



bei Gasheizwerten von 9 bis 12 MJ/m³

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GNS

Wirksamkeit der Rohgaswäsche mit Biodiesel für verschiedene Teerkomponenten

Komponente	Holzpyrolyse ohne Wäsche Experiment 30 [mg/m³]	Holzpyrolyse nach Wäsche mit Biodiesel Experiment 18 [mg/m³]	Holzpyrolyse Reduktion [%]	Strohpyrolyse ohne Wäsche Experiment 33 [mg/m³]	Strohpyrolyse nach Wäsche mit Biodiesel Experiment 27 [mg/m³]	Strohpyrolyse Reduktion [%]
Benzol	4491	363	91,9	370	39	89,4
Toluol	5332	129	97,6	1764	90	94,9
Ethylbenzol	347	5	98,6	268	5,8	97,8
m/p-Xylol	1156	25	97,8	781	23	97
o-Xylol	403	5,8	98,6	280	2,4	99,1
Styrol	480	12	97,5	209	2,9	98,6
C9-Alkylbenzole	697	14	98,0	272	4,4	98,4
Naphthalin	184	4,6	97,5	88	4,6	94,8
2-Methylnaphthalin	19	0,6	96,8	10	0,6	94
1-Methylnaphthalin	14	0,5	96,4	6	0,5	91,7

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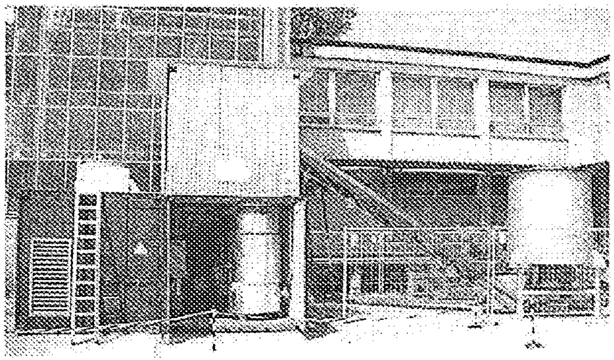
Forschungs- und Pilotanlage (50 kW_{el}), Campus Merseburg



Praxisprobleme mit Strohpellets:

Steigende Druckverluste im Reaktorbett durch Pelletabrieb

Aufquellen der Pellets nach Erkalten

Vorteile:

Temperaturbegrenzung durch Dampfzugabe

Vermeidung von Verschlackungen

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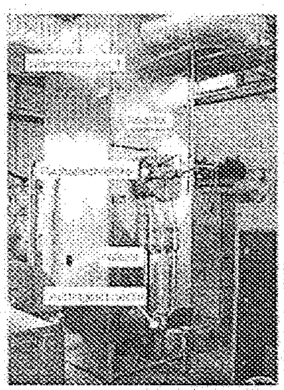
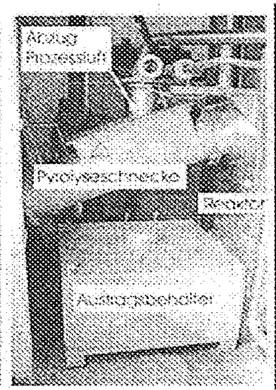
Versuchsanlage BENA 200 der Universität Halle





Praxisprobleme mit Strohpellets:

Verschlackungen im Wirbelbett

Vorteile:

Pyrolyseschnecke unempfindlich gegen Pelletabrieb

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Gaserzeugung aus Heupellets im Pilotmaßstab (Mittelwerte)

Parameter	Einheit	Halle	Merseburg	Merseburg[1]
Material		Stroh, mit Luft	Stroh, partiell-allotherm	Holz, katalytisch-partiellallotherm (Phase I)
Reaktortemperatur, ca.	°C	900	715-883	900
Durchsatz	kg/h	39	35	40
Gaszusammensetzung	Vol.-%			
CO		12,6	22,2	22
H_2		8,9	10,4	14
CH_4		3,6	3	2
CO_2		14,3	10,4	15
O_2		0,0	0,0	0
N_2		60,6	54,1	47
Heizwert (H_u)	MJ/Nm³	3,9	5,0	5,0
Gasvolumenstrom	Nm³/h	91,8	66	95
Gasausbeute	Nm³/kg	2,4	1,9	2,4
Brennstoffleistung	kW	162	147	167
Gasleistung	kW	98	92	132
Energieausbeute	MJ/kg	9,1	9,4	11,9

1: Erste Phase der Umsetzung des GNS-Verfahrens mit Holz

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Untersuchung des Verbleibs und der Entfernung des Brennstoffstickstoffs bei der Vergasung

Brennstoff	Holz	Strohpellets	Strohpellets
Gasreinigung	Wasser	Wasser	RME
NH_3 im Rohgas [g/Nm³]	0,23 – 0,72	4,3 – 7,1	4,3 – 7,1
NH_3 im Reingas [g/Nm³]	0,17 – 0,41	0,92 – 1,38	2,7

Versuche an 3 Pilotanlagen

Gegenüber Holz: bei Stroh ca. 10-facher NH_3-Gehalt im Rohgas !

70 bis 90% des Brennstoffstickstoffs als Ammoniak im Rohgas !

Reinigungsleistung der Wasserwäsche und RME-Wäsche für Ammoniak aus Strohvergasung unzureichend !

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Zusammenfassung

Hohe Energieeffizienz der Vergasung von Stroh mit niedrigem Teergehalt im Rohgas möglich!

- Weitere Verbesserung der Energieausbeute durch den Einsatz des katalytisch-partiellallothermen Verfahrens von GNS möglich

Anforderungen an die Vergasung von Stroh:

- Vortrocknung auf <10% als Voraussetzung für eine hohe Gasqualität und hohe Energieeffizienz der Vergasung
- Kompatierung/Pelletierung mit niedrigem Feinanteil als Voraussetzung für den Einsatz im Festbettreaktor
- Vermeidung der Verschlackung: Temperaturbegrenzung in der Reaktolyse und Vermeidung von Temperaturspitzen am Lufteintritt durch Dampfzugabe in Kombination mit vorgewärmter Luft im GNS-Verfahren hat sich bewährt
- Anpassung der Gasreinigung zur Entfernung der gegenüber Holz deutlich höheren Anteile an anorganischen Komponenten wie Ammoniak
- Anpassung der Gasreinigung hinsichtlich der Staubabscheidung
- Anpassung der Reaktordimensionierung an den Aschegehalt

Gesellschaft für Nachhaltige Stoffnutzung mbH GNS

Vielen Dank für Ihre Aufmerksamkeit

www.GNS-Halle.de

Characteristics of straw compared with wood

- **Distinction in form, firmness, bulk density and power density**
  - Effect on storage (dust formation),
  - Throughput (power density of straw chaff approx. 0.8 GJ/m ^{3}, of wood approx. 4 GJ/m ^{3}),
  - Dosage and gasification behavior (ua pressure losses in the fixed bed reactor),
  - Dust content in the raw gas
- **Increased ash content of straw opposite wood**
  - 5 – 15 fold higher ash content of straw opposite wood,
  - Slagging inclination by the high alkali content (ash softening < 800 °C)
- **Increased content of N, Cl, S of straw and grain opposite wood**
  - fuel-causes higher impurities of n, S and Cl-connections in the raw gas than with wood, with effects on the gas cleanup

Exhibit D

AN ENCYCLOPAEDIA BRITANNICA COMPANY

Merriam-Webster

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Dictionary

baffle

?! Quiz

Test Your Vocabulary

Take Our 10-Question Quiz

baffle

Save Popularity

1) baffle (verb)

2) baffle (noun)

baffle gate (noun)

²baffle noun

Definition of BAFFLE

: a device (as a plate, wall, or screen) to deflect, check, or regulate flow or passage (as of a fluid, light, or sound)

— baf·fled adjective

See baffle defined for English-language learners »

First Known Use of BAFFLE

1881

Other Audio Recording Terms

dub, fidelity, transcription, treble

Rhymes with BAFFLE

raffle, snaffle

Learn More About BAFFLE

Thesaurus: All synonyms and antonyms for "baffle"

Spanish-English Dictionary: Translation of "baffle"

X. RELATED PROCEEDINGS APPENDIX

None.